BULLETIN

OF THE

Society for the

Promotion of Engineering Education

Vol. I LANCASTER, PA., DECEMBER, 1910 No. 5

## EDITORIAL.

*Technical and Industrial Education.*—The paper by Professor Kimball, printed in this issue, represents the results of long and careful study of the subject from a number of different standpoints. As Works Manager for the Stanley Electric Manufacturing Company, the author had opportunity to observe the results of technical and industrial training. As apprentice, draftsman and designer he saw the matter from a second point-of-view. As head of a large technical school department which is vitally related to the industries, he is forced to study the relations of technical training and manufacturing. Taken in connection with the papers of Mr. F. W. Taylor, Mr. C. B. Going, Dean Herman Schneider and others, Professor Kimball's paper gives a clear presentation of the underlying principles involved.

*The Membership List.*—By action of the Council, the membership list is to be printed separately this year. It will appear as the January number of the BULLETIN. A return postal card, giving name, title and address, has been sent to each member with the request that it be returned at once to insure accuracy in the list. The members who have overlooked this matter should attend to it at once.

*The University and the State.*—The symposium presented

at the Madison meeting by Professors Pence, Mack and Burgess aroused a great deal of interest but the time allotted to the papers was necessarily so short that very little opportunity for discussion was afforded. In order that written communications may be printed in the PROCEEDINGS, the publication of the latter has been postponed about three weeks. Such contributions will therefore be accepted by the Publication Committee up to December 20.

*Timely Articles.*—The attention of the members is directed to two articles in the issue of SCIENCE for October 28. The first, an address delivered at the opening of the college year at Columbia University, is by Dr. Henry F. Osborn. Its title is "Huxley on Education." Among a number of powerful statements is this: "*Productive thinking* is the chief *means* as well as the chief *end* of education, and the natural evolution of education will be to develop this kind of thought earlier and earlier in the life of the student. The second article, by Professor Sydney Gunn treats of "American Educational Defects." It contains many stimulating suggestions.

Mr. Fred. A. Halsey's editorial article in AMERICAN MACHINIST, October 27, on "Training Mechanics in Germany" gives the result of careful personal investigation.

*The Treasurer's Statement.*—It is interesting to note the condition of the finances early in the year and to learn that bills are being paid promptly. The large amount still owing for dues indicates that members have forgotten that these are due July 1. For the convenience of the members the bills are not sent out until October 1. The Executive Committee, which has undertaken to furnish the BULLETIN free this year, requests cooperation by prompt payment of dues. This will show that the BULLETIN is appreciated.

*Local Meetings.*—It has been suggested from time to time that members should meet in the different centers for discussion of Society papers. This practice would stimulate interest in the work of the Society and it would enhance the value of the papers. As a comparatively small proportion of the membership can attend the annual convention, such meetings seem

necessary if the membership as a whole is to be vitally interested in the work. Several of the scientific and technical societies now have local sections and branches with the natural result that their work as a whole is greatly benefitted. Among these may be mentioned the American Chemical Society, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. While it is not proposed that the Society for the Promotion of Engineering Education form such branches or sections at this time, there is no doubt that informal meetings for discussion of the papers would prove profitable. By inviting to these meetings the non-members of the community, interest in the work of the Society would spread. Will not a member in each center shoulder the responsibility of calling a preliminary meeting for the purpose of taking up this suggestion? Invite to this not only the teachers of technical subjects but also those who teach allied subjects, and thus promote a spirit of cooperation.

*New Members.*—Since the last issue of the *Bulletin* fifty new members have been elected and approximately the same number of applications are now pending. Among those who are joining the Society are many who are the leaders in various lines of work. A fair proportion are non-teaching engineers. One feature of the growth of the membership is the steady flow of applications into the secretary's office. This is due to the loyalty of the members as a whole. They believe in the Society and are anxious to extend its scope and influence. Some time ago the Secretary sent out a request for suggestions as to persons who might appreciate an invitation to join. Nearly one hundred lists were sent in, and letters have been written to at least five hundred possible applicants. The new membership committee, which has not yet been fully organized, believes that a membership of one thousand should be reached at once. If they succeed in increasing the enrollment to this number they will have done the Society a good service in making possible a considerable enlargement in its work. The new members are cordially invited to take an active part in the work of the Society.

## APPLICANTS FOR MEMBERSHIP.

ADLER, A. A., Instructor in Mechanical Drawing and Designing, Polytechnic Institute of Brooklyn, Brooklyn, N. Y..... 1910

BIRD, WM. W., Professor of Mechanical Engineering, and Director of the Washburn Shops, Worcester Polytechnic Institute, Worcester, Mass. ..... 1910

BROWN, GEO. L., Dean of the Faculty, South Dakota State College of Agriculture and Mechanic Arts, Brookings, S. D..... 1910

CHASE, L. W., Professor of Agricultural Engineering, University of Nebraska, Lincoln, Nebr..... 1910

CHURCH, E. F., JR., Professor of Machine Design, West Virginia University, Morgantown, W. Va. ..... 1910

CRUCHAGA OSSA, ENRIQUE, Castro 49, Santiago de Chile, South America ..... 1910

DAWSON, F. M., Instructor in Civil Engineering, Nova Scotia Technical College, Halifax, N. S..... 1910

DENNIS, L. M., Professor of Inorganic Chemistry, and Head of Dept. of Chemistry, Cornell University, Ithaca, N. Y. ..... 1910

DOUGLAS, J. F. H., Instructor in Electrical Engineering, Cornell University, Ithaca, N. Y..... 1910

FOGG, R. J., Instructor in Civil Engineering, Lehigh University, South Bethlehem, Pa. ..... 1910

FOOTE, F. S., JR., Instructor in Railway Civil Engineering, University of Illinois, Champaign, Ill..... 1910

HEIDENGER, H. W., Instructor in Mechanical Engineering, University Extension Division, University of Wisconsin, Oshkosh, Wis. ..... 1910

HUBBARD, J. C., Assistant Professor of Physics and Head of Department, Clark College, Worcester, Mass..... 1910

JABLOW, CHARLES, Assistant in Mechanical Drawing and Machine Design, Kansas State Agricultural College, Louisville, Kentucky ..... 1910

JOBSON, A. J., Superintendent Bear Lake Construction for the Telluride Power Co., P. O. Box 221, Montpelier, Idaho..... 1910

KELLER, A. R., 1560 Magazine St., Honolulu, T. H..... 1910

LAHMER, J. A., Principal Assistant Engineer, The Kansas City Southern Railway Co., Kansas City, Mo. ..... 1910

LEBARON, J. F., Consulting Engineer in General Practice, Ipswich, Mass. ..... 1910

LUND, JACOB, Supt. Heat and Power Dept., Kansas State Agricultural College, Manhattan, Kan. ..... 1910

LUND, JAS. C., Assistant in General Engineering Drawing, University of Illinois, Urbana, Ill..... 1910

MILLER, F. G., Professor of Forestry and Dean of School of Forestry, University of Washington, Seattle, Wash. ..... 1910
MURDOCK, H. E., Instructor in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. ..... 1910
PARKER, F. Y., U. S. Assistant Engineer, United States Engineer Office, Custom House, St. Louis, Mo. ..... 1910
PAYNE, W. S., Instructor in Mechanical Engineering Department, University of Nebraska, Lincoln, Nebr. ..... 1910
RASMUSEN, J. E., Adjunct Professor of Mechanical Engineering, University of Nebraska, Lincoln, Nebr. ..... 1910
RICHEY, J. J., Instructor in Civil Engineering, University of Illinois, Urbana, Ill. ..... 1910
RICHTMYER, F. K., Instructor in Physics, Cornell University, Ithaca, N. Y. ..... 1910
ROBINSON, A. A., President of the Mexican Central Railway, 900 Tyler St., Topeka, Kan. ..... 1910
SCIPIO, L. A., Adjunct Professor of Mechanical Engineering, University of Nebraska, Lincoln, Nebr. ..... 1910
SHANKLAND, E. C., Civil Engineer, Firm of E. C. and R. M. Shankland, 4808 Champlain Ave., Chicago, Ill. ..... 1910
SLAYMAKER, P. K., Assistant Professor of Applied Mechanics and Machine Design, University of Nebraska, Lincoln, Nebr. ..... 1910
SMITH, J. E., Instructor in Civil Engineering, University of Illinois, Urbana, Ill. ..... 1910
STEWARD, R. K., Instructor in General Engineering Drawing, University of Illinois, Urbana, Ill. ..... 1910
WALKER, CHAS. L., Assistant Professor of Applied Mechanics, College of Civil Engineering, Cornell University, Ithaca, N. Y. ..... 1910
WHITE, A. E., Instructor in Mathematics, 712 Poyntz Ave., Manhattan, Kan. ..... 1910
WILLIS, PAUL, President Kenwood Bridge Co., 4857 Madison Ave., Chicago, Ill. ..... 1910
WOODS, H. C., Instructor in General Engineering Drawing, University of Colorado, Boulder, Colo. ..... 1910

Total ..... 37
Total since Madison Meeting ..... 90
Total including Madison Meeting ..... 197

By letter ballot the Council has acted favorably upon the 50 applications listed in the October and November issues of the BULLETIN.

## IN MEMORY OF STILLMAN WILLIAMS ROBINSON.*

Stillman Williams Robinson, emeritus professor of mechanical engineering, died on Monday morning, October 31, 1910.

Professor Robinson was born on a farm near South Reading, Vt., March 6, 1838. His early life was that of a country boy, but his love of mechanics led him to the shops and he served a four-year apprenticeship to the trade of machinist.

He earned the money to defray the expenses of his early education and to prepare himself for college. In 1860 he left home to attend the University of Michigan. He made the journey largely on foot and met his expenses by working as a machinist on the way and arrived at Ann Arbor with fifty dollars more than the eight with which he started.

He graduated from that university in 1863 with the degree of civil engineer, having supported himself through his college course by his skill as an instrument maker, in particular graduating thermometers. This led to his first invention, made while in college, of a machine for graduating such instruments. Notwithstanding the difficulties under which he labored, he earned the reputation of a brilliant and original student.

After graduation, he entered the government service as assistant engineer in the U. S. Lake survey, remaining in that service until 1866, when he returned to the University of Michigan as instructor in engineering.

He left the University of Michigan in 1870 to become professor of mechanical engineering and physics in the Illinois Industrial University, now the University of Illinois. There he established the Department of Mechanical Engineering which was the first to be established in this country.

* This biographical sketch of the life of the late Professor Robinson was prepared by a committee of his colleagues at the Ohio State University, Professors N. W. Lord, Edward Orton, Jr., and Wm. T. Magruder.

It is of interest to note as illustrating his versatility that while there he designed and constructed the tower clock now furnishing time at the University.

In 1878 he occupied the position of dean of the College of Engineering at that institution. The same year he was called to the Ohio State University as professor of physics and mechanical engineering, occupying that chair until he resigned in 1895 in order to devote his time to his extensive professional interests. In 1896 in consideration of his distinguished services as a scientific inventor, investigator, and writer, the Ohio State University conferred upon him the degree of doctor of science and in 1899 elected him emeritus professor of mechanical engineering.

Professor Robinson was a man of great originality and inventive genius. He secured about forty patents, many of which were based upon scientific research and mathematical investigation, the results of skillful study. They were designs rather than accidental discoveries. He was also the author of important books and papers presented before learned societies which are marked by the same quality of thorough research and originality. When the Ohio gas fields were first discovered the problem of measuring the volume of flow was referred to Professor Robinson and solved by him in his brilliant application of the Pitot tube, resulting in the methods now in universal use.

His interest in education was always great and led him in 1890 to organize an association composed of mechanical engineering teachers which in 1893 developed into the present Society for the Promotion of Engineering Education. His interest and love for the University did not cease with his retirement. He made at various times valuable donations to the equipment of the Department of Mechanical Engineering and finally established the Robinson Fellowship in Engineering as a permanent foundation.

As a man, Professor Robinson was an indefatigable worker. There was no limit to his enthusiasm and ambition in his profession. Personally he was modest and retiring, never claim-

ing credit for himself though most generous in according it to his associates. His nature was deeply sympathetic and very kindly. He was inflexible in his devotion to his duty and to his principles of integrity and honor. He was greatly interested in the work and success of those around him, both colleagues and students, and impressed his own enthusiasm upon their efforts, encouraging, stimulating and rewarding them. His memory and influence will long be felt in the lives of those who follow after him and have taken up his work where he left it.

## UNIVERSITY OF NORTH DAKOTA INAUGURAL.

Frank L. McVey Ph.D. (Yale), a graduate of the Ohio Wesleyan University, a former instructor in the Teachers College of Columbia University, and recently a well-known member of the faculty of the University of Minnesota, was formerly inaugurated as president of the University of North Dakota at Grand Forks, on September 29. On this and the two previous days, various appropriate and contributing exercises were held, including the dedication of two fine new buildings for the use of the University. One of these buildings is a teachers' college and the other a commons hall, planned to furnish boarding and luncheon facilities for as many of the faculty and students as may care to use it. During the three days, speeches and addresses were made by many wellknown educators, by two great railroad managers, by trustees, and by deans of various branches of the University work, and by the governor and other state officers of North Dakota. Especially notable and impressive were the addresses of President Elliott of the Northern Pacific Railway, of Director James J. Hill of the Great Northern Railway, of President MacLean of the University of Iowa, of President James of the University of Illinois, and the inaugural address of President McVey. Several of the speakers advocated thorough training in the fundamental sciences pertaining to all the modern professions, and included in these professions not alone the older standard professions and the modern lines of engineering pursuits, but also many of the occupations now classed as business callings. Training in the philosophy and the arts of these various professions was contrasted with training in the mere practice of the same professions without fundamental reasons for the methods employed. The functions of the real university as distinguished from the trade or vocational school was emphasized. Investi-

gation and original research were asserted to be the real life of a university. The advantage to a state of having its young people properly trained, and that by the state's own institutions, was pointed out. In fact, practically all of the many speeches were well worthy of very careful study in their entirety.

The attendance was both notable and large, even for such an occasion. Representatives of many other colleges and universities were present from both state and private institutions. Not a few came from considerable distances. Most of the larger institutions at a distance however were represented by some of their well-known graduates now living in near-by states. Quite a number of the learned societies, engineering associations, and similar bodies were also represented by regularly-appointed delegates, some being present from far-eastern states. The writers bore the greetings of the Society for the Promotion of Engineering Education at the request of its officers. All of the delegates were most cordially received and entertained by the various members of the faculty of the University. The people of the city, and especially the Grand Forks Commercial Club, showed the visitors and delegates many marked favors and added much to the enjoyment of the three days. Among these were a very fine banquet, automobile rides about the city, and luncheons. Those who met Dr. McVey for the first time were most agreeably and forcefully impressed with his personality and his fitness for the high position to which he has been called. His old friends knew this before. The University, the "baby elephant" of one of the speakers, was a surprise and a gratification to those of us who did not before know of its real substantial growth and its present attainments. The University faculty, the people of Grand Forks, and the city itself, all came in for our sincere admiration. Each and all of the above received not only our congratulations as delegates of the Society but also our personal best wishes and good will.

HENRY T. EDDY,
BYRON B. BRACKETT.

## LETTERS TO THE EDITOR.

EDITOR S. P. E. E. BULLETIN:

I should like to have the members of the Society express themselves in the BULLETIN in regard to the following proposed changes in two very common customs.

1. It has been customary to use the expression "polar coordinates" to designate the two quantities that determine the position of a point in a plane with reference to a fixed line and a fixed point on this line. At the same time we speak of the "radius vector" and the "vectorial angle." It would be simpler, more accurate and more suggestive to designate these coordinates as *"vector coordinates."* The student must learn, some time, what a vector is, and here is an opportunity to show him a real vector, *i. e.*, a directed magnitude. The same is true in three dimensions where we have two directions and a magnitude. Let us therefore avoid the confusion that always arises regarding the "polar of a point," the "equation of the polar" and the "equation in polar coordinates." The clearing away of this confusion takes much time and energy to no purpose. Why not, then, drop the unsuggestive and confusing term "polar coordinates," and use the true, suggestive term *"vector coordinates?"*

2. It would be a great saving of time and energy if all engineers and teachers would agree to call *east* the *zero azimuth*, and let the azimuth increase counter-clockwise, like any other angle, through northwest and south. Then the students who are taught in trigonometry, analytic geometry and physics, that positive rotation is counter-clockwise and that the angles are measured through the four quadrants, beginning at zero in the direction of the positive end of the $X$-axis, would not, when they came to study surveying, have to readjust their ideas, to begin somewhere else with zero and go in the opposite direction. We generally think of the positive end of the $X$-

axis as eastward on a map. This is convenient but not necessary. Conventions should be adopted that will cause as little friction and readjustment as possible to the beginner, who needs all of his brain power to grasp new ideas. The present generation might suffer some inconvenience but the future generations would be saved much time and annoyance by having the same system in all things pertaining to angles. The best transits are numbered both ways around the circle and *one* standard way would be better, and cause fewer errors.

The desire that prompts these suggestions is that we should use simple, direct methods and utilize the knowledge gained at one point to the fullest efficiency at every other point of attack.

FRANK B. WILLIAMS.

CLARK UNIVERSITY,
WORCESTER, MASS.

EDITOR S. P. E. E. BULLETIN:

I wish to suggest the inclusion, in the PROCEEDINGS of the Society, of a bibliography of engineering education for the year covered by a volume.

H. T. CLIFTON.

THROOP ACADEMY,
PASADENA, CAL.

In line with this suggestion, which is excellent, comes a note from Professor H. W. Tyler, calling attention to the vice-presidential address of E. W. Hobson, of the British Association for the Advancement of Science. This is printed in SCIENCE, September 23, 1910, and is an excellent presentation of the significance and tendencies of modern mathematics.—ED.

## TREASURER'S MID-YEAR STATEMENT.

To the Members of the Society:

The treasurer begs to report as follows with reference to the financial condition of the Society for the Promotion of Engineering Education, on November 1, 1910.

| | |
|---|---|
| Cash on hand in Lincoln Trust Co., | $ 703.25 |
| Bills Receivable (dues), approximate, | 2,061.50 |
| Proceedings, | 45.17 |
| Advertising, | 104.00 |

It is difficult to estimate exactly the outstanding obligations, but they are covered by the cash in hand. It will, however, be necessary to collect a considerable sum to meet the printing bills of the next few months. The Bulletin publication involves an expenditure of considerably over $150.00 per month, but with the cooperation of advertisers and members we shall be able to carry this if dues are paid promptly. If, therefore, you have overlooked this matter, kindly attend to it, thus saving trouble and expense to the Society. The Society is to be congratulated upon the prospect of a satisfactory financial year.

Respectfully,

Wm. O. Wiley,

*Treasurer.*

## COLLEGE NEWS.

*Dartmouth College.*—The Thayer School of Civil Engineering has issued an interesting Annual for 1910. It gives a very complete record of the alumni, details of the work of the Thayer Society of Engineers, a calendar of college events, etc. This annual is evidently a strong bond between present and former students and the faculty.

*Franklin Union* (Boston, Mass.).—The extent to which the faculties of engineering schools have been drawn upon to furnish instructors for evening educational classes is well shown by a glance at the names on the instructing staff at Franklin Union, an independent evening continuation school in Boston. The list includes the professor of steam engineering from the Worcester Polytechnic Institute, the professor of structural engineering and a number of instructors from the engineering department of Tufts College, an associate professor of machine design and several instructors in mechanical engineering from the Massachusetts Institute of Technology, and two instructors from the Harvard Graduate School of Applied Science.

*University of Idaho.*—Mr. D. B. Sleinman, formerly tutor in engineering courses in the College of the City of New York, has been appointed instructor in civil engineering in the University of Idaho at Moscow, Idaho.

*University of Illinois.*—A scholarship valued at $1,000 a year for advanced work in architecture has been made available to the trustees of the University of Illinois by Mr. Francis John Plym, of Niles, Mich. The conditions under which this scholarship is to be bestowed will be determined by the trustees. For the present it is understood that it will be given each year to a graduate of the department of architecture for the purpose of foreign study and travel.—The University is rallying to the support of the Society in securing

new members. On April 1st it stood second in the list with 26 members. This year it will be first, from present indications. Twelve applications have come in the past few weeks, largely through the efforts of Professor J. M. White.

*Iowa State College.*—The Engineering Division has just completed, ready for use, an Engineering Annex Building, 50 ft. by 200 ft., and a new Ceramics Building, 50 ft. by 70 ft. The two are connected. The annex accommodates the departments of surveying, civil engineering, drawing, and a considerable portion of the department of electrical engineering. Fifty feet at one end are given up to the work of the mining engineering department, and with that portion the Ceramics Building is directly connected. The work in ceramics at the Iowa State College is under the department of mining engineering, and has recently been introduced in obedience to a law passed by the State Legislature. The Ceramics Building is now being equipped.—Dean Marston has been conducting correspondence with the engineering alumni of the institution during the past year, the scope of which is indicated by copies of the circular letter and blank sent out. The statistics concerning the alumni collected, as given on the blanks returned in answer to this letter, are now being compiled, and show very gratifying results as to the success of the men. The text of this letter follows:

*Dear Friend:* I wish to extend greetings and cordial good wishes from your Alma Mater, and to ask you to do us the favor of filling out the enclosed blank. I desire the information to prepare a directory of the alumni of the Engineering Division. We hope to publish this directory in some form which will make it available to all the alumni.

I also wish to ask the favor that you communicate with us from time to time, telling us all about yourself and your work and making any helpful suggestions that may occur to you regarding our work at the college in the education of engineers. We feel that active cooperation between the alumni and the faculty can aid much to improve our work, and we know that the loyalty of the alumni is such that they desire to do everything in their power to advance the College and the Division of Engineering.

Yours very truly,

A. MARSTON.

The alumni are asked to supply the following items of information: (1) Name. (2) Class. (3) Business address. (4) Resident address. (5) First position held after graduation and salary or wages of same. (6) Present position or employment. (7) Salary or estimated annual income. (8) Do you wish to make a change? (9) If so, what kind of a position do you wish to secure? (10) What minimum salary would you consider in making a change to your liking? (11) Give names of former employers whom you would suggest as references. (12) To what professional societies do you belong? (13) Additional remarks. (Relating to your experience between graduation and the present, etc.)

*University of Mississippi.*—Large additions to the electrical equipment are now being installed and will soon be ready for use. A complete outfit for testing road materials has also been purchased for use in the civil engineering laboratory, besides considerable increase in the surveying outfit and the equipment of the cement laboratory. There is a considerable increase in the attendance upon the engineering classes this year, and what is better, the grade of students seems to be far above the average.

*University of North Carolina.*—The following appointments have been made in the engineering departments: Parker H. Daggett, S.B. (Harvard, 1907), associate professor of electrical engineering; Vivian L. Chisler, S.M. (Nebraska, 1909), instructor in physics; Marvin H. Stacy, A.M., promoted to full professorship of civil engineering; Thomas F. Hickerson, A.M., promoted to be associate professor of mathematics.

*Purdue University.*—During the vacation season of 1910, extensive changes in the shops and laboratories have been carried out. The completion of the new shops having a total floor area of about 70,000 square feet and capable of accommodating about 400 students at one time, has set free the rooms formerly occupied by the shops, for laboratory purposes. A concrete and cement laboratory, 40 by 70 feet, will accommodate the work of preparing and testing these materials. The steam engine laboratory has been extended so that

its area is nearly doubled and it will furnish room for heating and ventilating experiments. The gas engine laboratory, 40 by 80 feet, contains a producer, ten engines of various types and is provided with a reinforced concrete testing floor for the accommodation of small engines. The hydraulic laboratory, 50 by 100 feet, will take the place of the former wood shop. These changes will allow the University to accommodate at one time nearly twice as many students in laboratory and shop work as formerly.

*Throop Polytechnic Institute.*—"Pasadena Hall," the first of a group of buildings planned for the new campus, is now in use. It is a building of massive concrete construction, costing $160,000, and containing 800,000 cubic feet of space. It is divided into sixty-two rooms. The preparatory school has been segregated in the old buildings under the name of *Throop Academy,* and the entire forces of the Institute will be concentrated on the problem of building for southern California an engineering college of the highest grade.—Among the changes in the faculty the following are noted: R. W. Sorensen, formerly of the General Electric Company, has been appointed associate in electrical engineering; Chas. H. Kicklighter, formerly of the University of Florida, has been appointed associate in mechanical engineering; Professor L. H. Gilmore has been made acting director of the Department of Engineering.—Bulletin No. 47 describes the dedication exercises in Pasadena Hall and has as frontispiece a beautiful half tone of the building.

*Washington University* (St. Louis, Mo.).—The new forge, foundry, pattern and machine shops were built and equipped during the recent summer vacation. The shops occupy two wings that were added to the Cupples Engineering Laboratory, one at either end. Each wing covers sixty by fifty-two feet, the east wing, for forge and foundry work, being one story high, while the west wing, for pattern and machine shops, is two stories high. The foundry equipment consists of a cupola having a melting capacity of one ton per hour, an elevator and charging platform, an overhead trolley with

a one-ton triplex block, two molding pits, a core oven, a tumbler, ten portable molding machines, and flasks and miscellaneous small tools for a class of twenty-four students. The forge shop contains twenty down-draft forges, arranged in pairs with a common exhaust and separate blowers; one large forge, a 100-pound power hammer, a power punch and shears, a tempering forge, and the usual complement of small tools. The pattern shop is equipped with twelve in. by 4 ft. speed lathe, one 25 in. and 50 in. by 8 ft. pattern maker's gap lathe, one band saw, one universal saw bench, one jointer, and eleven double work benches, 6 ft. by 3 ft., each provided with two side and two end vises, and drawers for small tools. The machine shop is thoroughly equipped with the latest and best types of machine tools, as follows: eight 14 in. by 6 ft. engine lathes of different makes and with quick-change gears; one 14 in. by 5 ft. tool room lathe; one 14 in. by 6 ft. patent head engine lathe with variable speed, individual motor drive, for experimental purposes; one 24 in. by 10 ft. engine lathe; one No. 1 Hollow Hexagon turret lathe; one 33 in. by 33 in. by 8 ft. planer; one 22 in. by 22 in. by 6 ft. planer; two 16 in. shapers; one universal milling machine and one plain milling machine; one horizontal boring, drilling and milling machine with single belt drive and patent speed box; one 24 in. radial drill with patent speed box; one universal grinding machine; one universal drill grinder; one water tool grinder; one 24 in. back-geared, sliding head drill press; one 20 in. lever and wheel feed drill press; one sensitive drill; a power hack saw, and a complete equipment of chucks, drills, taps, dies, reamers, arbors, gauges, etc.

*Williamson Trade School.*—The school recently issued a circular containing information intended as an answer to the question, "Can trades be taught in school?" The following record is that of the class of 51, graduated March 26, 1910. The record includes 50 of those graduated.

| Trade. | Average Hours per Week Employed. | Average Rate of Compensation per Hour. | Average Weekly Rate of Compensation. | Number at Trade. |
|---|---|---|---|---|
| 12 Bricklayers.... | 51 | 40.5 | $20.64 | All, and all like it. |
| 13 Carpenters..... | 51.6 | 30.6 | 15.81 | All like the trade and all but one working at it. He followed the trade some time, but is temporarily inspecting material in auto works and will return to trade later. |
| 4 Operating Steam and Electrical Engineers..... | 61.7 | 20.6 | 12.75 | All, and all like it. |
| 11 Machinists..... | 55.7 | 26. | 14.53 | All, and all but one like it. |
| 10 Patternmakers | 54.6 | 30.3 | 16.58 | All like the trade and all working at it but one, who is at mechanical drawing. |

General Averages:

Hours per week employed ..... 53.79

Rate per hour ..... 30.8

Weekly rate of compensation .....$16.60

One not heard from—carpenter—whom we learn indirectly is at mechanical drawing.

The following papers were presented at the eighteenth annual meeting, Madison, Wis., June 23, 24, 25, 1910. Written discussion is invited.

# CO-OPERATIVE WORK FOR THE WISCONSIN RAILROAD AND TAX COMMISSIONS BY MEMBERS OF THE ENGINEERING FACULTY, UNIVERSITY OF WISCONSIN.

## A. HISTORICAL AND DESCRIPTIVE.

By W. D. Pence,

Professor of Railway Engineering, University of Wisconsin.

The long-established policy of the University of Wisconsin in permitting and encouraging members of its instructional staff to take an active part in the scientific work carried on by various departments of the state and national governments has seen a notable extension within the past few years, particularly in directions pertaining to engineering work. As illustrating this policy, it is the purpose of this paper briefly to describe the work done by members of the engineering faculty in cooperation with the Wisconsin Tax and Railroad Commissions.

This cooperative work began in connection with the initial steps in the administration of the assessment law of 1903 which provided for the substitution of the *ad valorem* for the gross earnings basis for taxing the steam railroads of the State. Under the terms of that law it became necessary to have trustworthy information as to the fair valuation of each of the various railroad systems within the State, and to this end the Tax Commission in June, 1903, engaged as its engineer expert Prof. W. D. Taylor,* professor of railway engineer-

* Professor Taylor served as the commission's engineer until February 1, 1906, when he resigned to become chief engineer of the Chicago and Alton Railroad.

ing, University of Wisconsin. Professor Taylor had previously (in 1901) rendered a similar service in arbitrating some disputed points with respect to the physical valuation of certain railway properties in northern Minnesota involved in rate investigations then being made by the Railroad and Warehouse Commission of that state. Before severing his connections with the Wisconsin work he was engaged at intervals upon two other important pieces of work touching the interests of the state or federal government. The first of these was an expert field examination of the physical and operating features of the principal steam railway lines of Wisconsin on behalf of the then retiring state railroad commissioner. The other consisted of field investigations on behalf of the Interstate Commerce Commission as to the valuation of railway properties in various parts of the United States. These latter studies were made in collaboration with Professor B. H. Meyer, professor of transportation in the University of Wisconsin, who was appointed to the Railroad Commission upon the creation of that body in 1905, and who subsequently became its chairman, in which capacity he is still serving. During Professor Taylor's service jointly for the University and the State, he was also able to engage at intervals in private professional practice by taking temporary leave from his duties for the Tax Commission subsequent to the completion of the initial valuation work of the steam lines in 1903-1904.

The initial organization of the engineering staff engaged in the physical appraisement of the steam roads of the State was based upon the three major divisions of the tangible property, viz., the lands, the permanent way and the rolling equipment. The valuation of right of way and other lands was placed in charge of Professor E. B. Skinner, of the Department of Mathematics, and that of the rolling equipment and associated features was assigned to Prof. J. G. D. Mack, professor of machine design in the University of Wisconsin. Certain other statistical studies relating in part to land valuations were early undertaken by Professor T. S. Adams, of the Economics Department of the University.

The work performed in the initial valuations by Professor Taylor has been described in detail in his report to the Wisconsin Tax Commission (Report of 1907) and the results of Professor Skinner's work are presented in his paper before the Wisconsin Academy of Sciences (*Proceedings,* 1906). Professor Mack, in a separate paper of today's program, is describing some features of the service originally performed under his direction for the State Board of Assessment and more recently over a still broader field jointly for the two state commissions.

In the legislative session of 1905 two laws were enacted which subsequently led to a largely increased demand for engineering services on behalf of the State. One of these laws provided for the *ad valorem* basis of taxation for the electric railways and the associated lighting and power plants, along lines similar to those established in 1903 for the steam roads of the State. The other was the law creating the Railroad Commission with regulative powers over rates and service of the transportation lines of the State. In framing the last-named law, it was foreseen that certain statistics relating to the steam road valuations would probably be needed in the work of the newly-created commission and provision was made in the Railroad Commission Law for the use of the data gathered in the office of the State Tax Commission. This relationship later assumed the more tangible and practical form of a joint agreement between the two commissions whereby the services of one engineer, and later on of an engineering staff of considerable size, was shared by the two bodies, with an apportionment of salaries and expenses according to the respective services rendered.

Under this arrangement the writer, as Professor Taylor's successor, assumed his duties on a cooperative basis for the University and for the two state commissions in July, 1906. The staff at that time consisted of the engineer, one engineering assistant and a stenographer, which force was found to suffice until it became necessary to take up the valuation of the electric roads of the state. This latter work was precipi-

tated some months earlier than originally planned through the filing of a complaint, in December, 1906, before the Railroad Commission, relating to rates charged by the Milwaukee Street Railway System, both city and interurban, and the valuation of these properties (involving a value of $18,000,000) was undertaken in January, 1907. To meet the requirements of this valuation work, the staff was reorganized under three principal groups or departments; civil, mechanical and electrical engineering. The size of the staff was at once increased from three to twenty-three persons. In making this reorganization several members of the teaching staff of the College of Engineering were appointed for special service, including, beside the engineer in charge, the following-named persons: In the civil engineering staff, Mr. Williams and Mr. Van Zandt, of the Railway Engineering Department; in the mechanical staff, Professors Mack and Vosskuehler, of the Machine Design Department; and Professor Thorkelson, of the Steam Engineering Department.

About the date of completion of the Milwaukee valuation above referred to (July, 1907), the Wisconsin Public Utilities Law was passed providing for sweeping extensions to the powers of the Railroad Commission. This law gives the commission regulative authority over all water, gas, electric, telephone and heating plants of the State, whether privately or publicly owned. Its more important provisions are: (1) adequate service at reasonable rates, free from discrimination; (2) establishment and enforcement of standards of service and units of measurement; (3) valuation of all utilities; and (4) uniform systems of accounting.

No active steps were taken by the Railroad Commission relative to the enforcement of the engineering features of the utilities law until late in 1907 after the initial valuations of the electric roads of the state for the joint purposes of the two commissions had been practically completed. As a matter of economy, and following out the policy previously established, it was decided to utilize the existing organization as far as possible and merely add such departments as were demanded

to meet the new features required by law. Modifications of the previous organization of the engineering staff were brought about by the terms of the Public Utilities Law to provide for the valuation of gas properties and the investigations and inspections of gas and electric service. Professor C. P. Burgess, head of the Department of Chemical Engineering of the University, was appointed expert in light and heat and placed in charge of these two departments of the work of the technical staff. Professor Burgess is presenting a review of this work to the present time in a separate paper.

Quite recently there has been further legislation extending the duties of the Railroad Commission with reference to grade crossing elimination and protection, and these extensions of authority, together with the necessity of revisions of the valuation work of the steam railway property have necessitated certain additions to the staff to satisfy the growing field of the work of the two commissions, particularly with reference to safety of railroad travel. The organization scheme as it now stands includes the following more or less distinct departments:

1. *Administrative,* consisting of the chief engineer, assistant engineer and heads of departments, responsible for the direction of the work.

2. *Office Staff,* engaged in the reduction of field notes, the compilation of valuation and other reports, and the systematic collection and filing of cost data and other records.

3. *Civil Engineering Staff,* engaged in the inspection and valuation of those details of the physical property of steam and electric railways and public utilities plants which are customarily purchased, constructed, or maintained under the direction of civil engineers; including such items as the following: Lands, track, track structures, and bridges; buildings and miscellaneous structures, such as gas holders, stand-pipes, reservoirs, dams, wells and foundations; earthwork and paving; pipe distribution systems for water, gas and steam heating plants including tunnels for same; office furniture and appliances; horses and wagons; tools, stores and supplies pertaining to the foregoing items; etc. Also investigations, in cooperation with other departments, with a view to suggest improvements in the operating conditions of railways, water works plants, etc.

4. *Mechanical Engineering Staff,* engaged in the inspection and valuation of those details of the physical property of steam and electric railways and public utilities plants which are customarily purchased, con-

structed or operated under the direction of mechanical experts or engineers; including such items as the following: Power plant machinery and equipment (exclusive of electrical features); steam and hot water plants (except street mains); steam road locomotives and rolling stock; shop machinery and tools; tools, stores and supplies pertaining to the above items; etc. Also investigations, in cooperation with other departments, with a view to suggest improvements in the operating conditions of water works, heating plants, power plants, etc.

5. *Electrical Engineering Staff*, engaged in the inspection and valuation of those details of the physical property of steam and electrical railways and public utilities plants which are usually constructed, purchased or operated under the direction of electrical experts or engineers, including electrical machinery and appliances in power plants and elsewhere; electric railway rolling stock; electrical distribution systems, overhead and underground; telephone plants; signaling appliances; tools, stores, and supplies related to the above items, etc. Also investigations, in cooperation with other departments, with a view to suggest improvements in the operating conditions of electric railways, power plants, telephone properties, etc.

6. *Gas Engineering Staff*, engaged in the inspection and valuation of machinery and appliances for the manufacture of gas; tools, stores and supplies pertaining to the same, etc. Also investigations, in cooperation with other departments, with a view to suggest improvements in the operating conditions of gas plants.

7. *Gas and Electric Service Inspectors*, engaged in inspections and investigations of gas and electric service; studies with reference to the establishment and revision of standards of service and the formulation of rules for the same; tests and calibrations of instruments used in service measurements; investigations with reference to the electrolysis of water and gas mains, etc. Also investigations, in cooperation with other departments, with a view to suggest improvements in the operating conditions of gas and electric plants.

8. *Railway Safety Staff*, engaged in inspections and investigations of those features of steam and electric railway properties which relate primarily to safety of travel, including the installation and operation of interlocking plants at crossings, junctions, and drawbridges; of block signals, highway crossing protection, and the like. Also the valuation of signaling installations.

9. *Miscellaneous.* Experts engaged temporarily for special service of various kinds, either independently or in cooperation with one or more of the foregoing departments. Such service hitherto rendered has included such matters as the following: Consultation with prominent architect relative to valuation of a costly city building; service of expert in investigations as to the safety of an important bridge; expert val-

uation of the horses, harness, etc., belonging to a large electric railway and lighting company; expert assistance in establishing a basis for valuing street railway special work; etc.

The basis of appointment of the staff is provided for in part by a formal rule of the Civil Service Commission, and in part by special authorizations given from time to time by the Railroad Commission for the employment of experts under the provisions of the public utilities and railroad commission laws. The designations or titles of the staff members is given below: Engineer in charge (for the two commissions), consulting engineer (for occasional service), assistant engineer (office engineer), civil engineer inspector, chief mechanical inspector, chief electrical inspector, railway safety service expert, expert on light and heat, field civil engineer inspector, field mechanical inspector, field electrical inspectors, inspector of gas service, inspector of electric service, assistant inspectors of gas and electric service, assistant field inspectors, experts (for occasional service), engineering computers, clerks and stenographers.

For reasons of economy or efficiency it has been found expedient in some cases temporarily to combine, and in still others to subdivide, the duties and responsibilities of certain of the positions given in the foregoing list. At the present time, for example, the assistant engineer performs the duties of office engineer and, in a measure, of the civil engineer inspector as well. Similarly, the expert on light and heat is at present chiefly responsible for the staff work of the two related departments of gas engineering and gas and electric service inspections. The duties of chief electrical inspector, on the contrary, are at present shared by two field electrical inspectors responsible for the inspections and valuations, one primarily of the electrical machinery and rolling stock group, and the other of the electrical distribution systems and telephone properties.

It should be stated that membership on the staff is based upon ascertained fitness for the special service for which the appointment is made. There is entire freedom from political

or other influence both in the matter of appointment and in the tenure of position on the staff. The tenure of service has been steady, the roll, except for the additions, being much the same as that established early in 1907. The practice followed by the commissions in other departments of service of requiring each employe to report daily the actual hours devoted to the state work, is observed by the technical staff.

The present membership of the technical staff of upwards of thirty men consists almost exclusively of graduates of engineering schools, and as should of course be the case, the permanent staff consists largely of graduates of the University of Wisconsin. Seven members of the regular staff are members of the faculty of the College of Engineering and other members of the teaching force render occasional or emergency service.

As already indicated, this is but one among many instances, in Wisconsin, of active participation by university men in professional service on behalf of the State. Such participation is encouraged by the Board of Regents and the President of the University, not only on account of the stimulus given to the work of the University through outside contact of this kind, but also because of a recognized obligation to the State which provides liberal financial support for the institution. In the state of Wisconsin there has perhaps been an unusual opportunity to draft the University into the service of the State due to the location of the institution at the capital city, but it is a noteworthy fact that in responding to the "call to service" but little disposition has been shown to draw false lines between so-called "private practice," and similar professional service rendered by faculty members on behalf of the commonwealth itself.

## B. MECHANICAL FEATURES.

BY JOHN G. D. MACK,
Professor of Machine Design, University of Wisconsin.

The work of the mechanical department of the joint engineering staff of the Wisconsin Tax Commission and the Railroad Commission of Wisconsin may be classified under three general divisions, as follows:

(*a*) Problems relating to the physical valuation of railroad and public utilities properties.

(*b*) Problems relating to the quality of service rendered by railroads and public utilities.

(*c*) Problems originating in certain aspects of rate determinations, in cooperation with the statistical department.

A brief statement of the more important work which has been done by the mechanical department is as follows:

(1) First valuation of all rolling stock, shop machinery and tools of the steam roads in Wisconsin, made in 1903–04. This included inspections of a portion of the rolling stock and all shop machinery on the large roads, and all rolling stock and machinery on about thirty small roads.

(2) A complete annual correction of inventory and revaluation of the rolling stock, tools and machinery of the larger roads, and the same for the small roads, including a detailed inspection of the latter.

(3) An inspection, inventory and valuation of the mechanical equipment of all the electric railway power plants in the state, the plants being operated by steam, gas, water power, or combinations of these powers.

(4) Same as (3) for a number of electric lighting and power plants.

(5) Same as (3) for a number of water works pumping plants operated by steam, electric and water power.

(6) Inspection, inventory and valuation of the mechanical portion of a number of gas works.

(7) Inspection, inventory and valuation of central steam

and hot water heating plants, in combination with power plants noted under (3) and (4).

(8) Division of cost of combined power plants, as for example, between water and electricity, or of a single plant, as a water works pumping station, between public and domestic service.

(9) Examination, computations and tests of water works pumping stations for adequacy of service and the fulfillment of franchise requirements, including suggestions for improvement in service.

(10) Preparation of plans and estimates for the improvement of a combined electric light and pumping plant.

(11) Investigation of complaints and examinations of systems regarding cost and efficiency of steam heating service.

(12) Investigation of plumbing and automatic sprinkler systems as related to alleged excessive use of water.

(13) Investigation regarding causes of certain locomotive boiler explosions.

(14) Investigation of locomotive maintenance.

(15) Detailed investigation of water works pumping station piping as regards possibilities of various water routes or sources of supply.

(16) Preparation of original forms and methods for taking inventory of the mechanical equipment of power plants.

(17) Investigation of various systems of depreciation of physical property with analytical and graphical analysis of same.

(18) Preparation of original graphical charts for the convenient calculation of average new and depreciated values of power plant, shop and rolling stock equipment.

(19) Compilation of statistics and expert opinions regarding life of power plant, shop and rolling stock equipment, with a view to a determination of average depreciation charges.

(20) An extensive study and compilation of costs, and average costs over a period of years of rolling stock and power plant equipment.

(21) Study of freight rates on and installation charges for power plant equipment, including graphic and tabular methods for convenient determination of these elements of cost.

(22) Investigation of the various factors influencing the cost of power in this state with special reference to the value of a water right.

(23) Investigation of sources of contamination of water supply.

In this work, as chief mechanical inspector in charge of the mechanical department of the commission's engineering staff, the writer has been assisted by members of the mechanical and other departments of the staff, and by H. J. Thorkelson, associate professor of steam engineering, and J. H. Vosskueheler, assistant professor of machine design of the College of Engineering, University of Wisconsin.

There is a close relation between many of the commission problems noted above, and various subjects given in the mechanical engineering course of the College of Engineering. This relationship has been of great value in the instructional work in steam engineering and machine design, but it is to be especially noted in connection with the commercial mechanical engineering course, required of seniors in mechanical engineering. A large amount of material bearing directly on this course has been obtained by the members of the faculty who have served on the engineering staff of the two commissions, in fact it was the direct outgrowth of this experience.

## C. GAS AND ELECTRIC SERVICE.

BY C. P. BURGESS,

Professor of Chemical Engineering, University of Wisconsin.

The Railroad Commission, during the past few years has been conducting an important line of engineering work in determining equitable rates for gas and electric service and in prescribing certain standards with which such service shall

comply. This work has been undertaken and carried on, at first, in the face of some hostility on the part of the public service interests, but later with a more genuine cooperation between the Railroad Commission and the public service companies.

The lines of work which were followed in arriving at the results desired were as follows: (1) Appraisal of physical values, (2) study of operating conditions and costs, (3) investigation of quality of service furnished by the various companies in this state, and (4) determination of those qualities of service to which the public was entitled in the existing state of the art, without placing unwarranted burdens upon the utility companies.

In the organization of the engineering staff of the Railroad Commission the engineering faculty of the University has contributed several of its members, who were assigned several branches of the work. The work for the commission occupied but a portion of their time. The industrial field has been canvassed by the commission for men suited to appointment on this staff. It is natural that the branch of the engineering staff having to do with gas and electric service should be composed largely of graduates of the University of Wisconsin and members of the engineering faculty. A few illustrations of the work done by these men will be given to show the nature of the tasks which have been encountered.

In considering suitable standards for gas service it was recognized that the heating value is a factor of greater importance in this state than was the more commonly used standard of candle power or illuminating value. It was found, however, that little was known about the calorific value of gas supplied to the cities in this state. A preliminary canvass of the cities receiving gas service was therefore made by university men employing equipment belonging to the College of Engineering. Having determined what quality of gas the well-managed companies were giving, it was not difficult to decide upon a standard which all companies could reasonably be expected to meet. This work brought out the fact that

there was no universally adopted standard of gas heating value; that there was a controversy as to whether "net" or "gross" values should be employed. It was also found that there was no one standard form of calorimeter in general use for making these measurements, and that certain forms of calorimeter on the market gave decidedly erroneous results. A lengthy laboratory investigation was therefore undertaken to determine which forms of calorimeters would best serve the purpose, from the standpoints of accuracy and practicability. This work was done in the chemical engineering laboratories and covered a period of more than two years. In this investigation cooperation was afforded by a committee appointed by the American Gas Institute. The results of this work have been presented in lengthy reports published by the American Gas Institute, and they have had a notable influence on gas calorimeter practice throughout the country.

The impression has been generally prevalent among gas men that the tendency for gas meters is to become slow in service. Tests upon a great many meters which have been in use showed a majority of them to be running fast, and upon study of the causes of this discrepancy between supposed and actual conditions it was found that the chemical quality of gas has something to do with meter performance. Discrepancies were encountered between tests on meters conducted by companies and those conducted by the Railroad Commission. A study of the causes of such discrepancies led to a careful investigation of methods of meter testing and this investigation is still being carried on with interesting and useful results. Most of the gas companies employ meter "provers" as standards for checking the accuracy of service meters. As these provers had never been standardized since being placed in the works, arrangements were made for calibrating them. For this purpose a one-half-cubic-foot bottle was designed and constructed in the mechanician's department of the University. It differs from the cubic-foot bottle ordinarily employed in that it is portable and thus can be carried by an inspector who visits the various cities. It was found, further, that by far

the greater number of complaints as to gas service were founded upon inadequate or greatly varying gas pressures. Investigation was made as to the pressures most suitable for general use, and standards for gas pressures were adopted.

In like manner, qualities of electric service have been studied. The deterioration of incandescent lamps in service and the methods of guarding consumers against unwarranted deterioration have been considered. Investigation and classification of complaints has been made and attention has been given to measurement of efficiency of various forms of street lighting.

Assuming for the moment that no one will care to deny that this work has been of great value to the people of the State, or that the University in sharing in this work has fulfilled an important public function, various other advantages which have come from this co-operation may be pointed out. A student's interest in his work is stimulated largely by his appreciation of its practical utility. The carrying on of work such as has been outlined, in the laboratories and under the observation of the student and frequently with his assistance, cannot fail to be an inspiration to him. The trend of instruction given to engineering students has been modified to a considerable degree as a result of this work for the State. In the Chemical Engineering Department, for example, a course of instruction in gas and fuel engineering has been worked out. This is a course of instruction suitable for training men for inspection service, as well as for employment with gas and electric companies. This instructional work is based largely upon actual observations of practice in this state. The instructional force of the University has been given an opportunity to study the arts, not only as pertaining to large and up-to-date installations, but to the numerous small ones, as well. The instructor is thus given an opportunity of getting in touch with a wider range of practice in a short time than he could get in most industrial positions. He is given reliable information as to costs, operating conditions, and the like, which information and experience he is able to impart

unreservedly to his students. In this respect the work for the State is more advantageous than is the work done by instructors in consulting practice for private parties, who naturally place some restriction upon the freedom with which such work may be discussed.

A criticism which has been made upon much of the research and investigation work carried on by universities is its remote relationship to present practice. No argument is needed to show that as high a grade of scientific and technical work may be done in dealing with problems of immediate practical utility as with those which are of only scientific interest. And there is perhaps no better incentive to the direction of investigative work along lines of immediate practical importance than is offered by cooperation such as has existed between the College of Engineering and the Railroad Commission of Wisconsin.

Written discussion on the above paper, if received before December 20, 1911, with the approval of the Editing Committee, will be printed in the PROCEEDINGS. Contributions should be brief and interesting and should add something to the subject.—ED.

# THE PROBLEM OF INDUSTRIAL EDUCATION.*

BY DEXTER S. KIMBALL,

Professor of Machine Design and Construction, Cornell University.

It must be evident to every thinking educator that our educational methods of all kinds are likely to be changed or modified in the very near future. Just what these changes and modifications are to be, and to what an extent they will affect different branches of our system, does not now appear clear; but the primary and secondary branches of our educational system will certainly be much changed and without doubt some readjustment must be made by the colleges and universities. The movement of which these prospective changes form a part is not new, but is simply an extension of the protest against the idea that any one fixed kind of educational curriculum is sufficient to prepare all manner of men for all manner of duties. Just as our existing professional colleges were called into existence by a demand for educational facilities which would prepare men more closely for the duties of life on the higher levels, so there is to-day a crying demand for the reorganization of the schools of lower grade in order that *all* boys and girls may receive a training which shall fit them more closely for the duties of life for which they are best adapted. There has long been a feeling in many quarters that the public schools failed not only in this respect, but failed even to hold the great mass of boys and girls in school

* In response to an invitation extended by President Talbot, Professor Kimball has prepared this paper as a contribution to the general discussion on the principles of technical and industrial education. Matters of this kind are most fundamental. They bear closely upon the central idea of the Society, which is to study the essential features of the subject. Professor Kimball is especially well qualified to write upon the subject, as he has been an apprentice, a designer, a college student, a professor and the works manager of a large industrial plant.—ED.

long enough to give them the rudiments of a decent education. Many statistics have been compiled to show the truth of these statements but perhaps none are more convincing than those compiled by James F. Barker, principal of the Cleveland Technical High School, from the schools of the city of Cleveland. He found that the number of children in the various grades were as follows: First, 14,509; second, 9,992; third, 9,530; fourth, 8,780; fifth, 7,702; sixth, 6,179; seventh, 4,974; eighth, 3,154; high first, 1,903; high second, 1,426; high third, 930; high fourth, 740. It will be noted that out of 14,509 children in the first grade, only 6,179 reached the sixth grade. *Over half the children went out into the world with less than a grammar grade training and that having little direct bearing upon their life's work.*

Perhaps in time the pressure from those who are to be prepared for life would have brought about the desired changes. But the movement has been greatly accelerated by the employing class, who, finding that changed industrial conditions no longer make it possible to train men in the industries by the old apprenticeship method, have thrown the burden of the preparation of industrial workers upon the schools. In the meantime, a great variety of private and public schools have sprung up in an effort to supply the deficiencies of the public school system. Many of these schools are the result of an effort to remedy local conditions and the total result has been a chaotic state of affairs. Now, while there is no doubt that all these efforts were absolutely necessary and will be exceedingly helpful in the way of gaining experience, they cannot be looked upon as other than temporary if we are to obtain the best results. Experience has shown us that education and educational problems are communal matters which cannot be left in the hands even of the parents, much less in the hands of private parties who are simply financially interested. If industrial education is necessary it should be supplied by the public school system and without doubt it will be so supplied finally.

In the meantime we are facing a formative period, a period

of readjustment, when pertinent questions are being asked by thinking men both in educational and industrial lines. Some of these questions must be answered before we can hope to bring order out of the present chaos; and it may be that we shall have to do considerable experimenting before definite answers can be advanced. Among the many questions involved in the movement, the following stand out somewhat above the others:

1. Have industrial educational methods as represented by our higher professional schools been justified?

2. To what extent can these methods be extended to the primary and secondary grades?

3. Shall the lower industrial schools be formed by remodeling our existing schools or shall they be organized separately?

The first question is not a new one, in fact it is an old bone of contention. The opinions expressed regarding this point are many and various, ranging all the way from the assertion that training in a technical school is essential for the modern engineer, to the flat contradiction that technical schools are an absolute waste of money and a delusion and a snare generally. While some of these extreme views are based on experiences more or less limited they are, for the most part, speculative and not in keeping with what experience we have had. Of the value and necessity of technical training, in a general sense, the writer believes the people of the country are firmly convinced. It is true that a good number of men of high standing in the industrial world, some of them technical graduates themselves, have severely arraigned technical education; and we are all only too well aware of the shortcomings of our best technical schools. It would indeed be a curious thing if they were perfect, for they would undoubtedly then be the only perfect organization where human attributes are a factor. Further, over against the evidence of this comparatively small number of extreme critics, who undoubtedly do the technical schools a world of good, must be set the experience of many thousands of manufacturers who, yearly, send their sons and

protégés to technical schools to prepare them for their life's work in the industries. Surely they cannot all be foolish or misguided and must have some good ground for such action. Practically the only way of entering the field of law or medicine is through the professional schools organized to teach the subjects and the same is true of many other fields. To deny the efficiency of technical education in general is simply an admission of ignorance of the subject.

It by no means follows, however, that any school or college can give *all* the training necessary for *any* position in the industrial field and the greatest trouble with both critics and advocates of this modern method of education is the failure of one to appreciate the benefits of the system and of the other to note its shortcomings. There are certain things the schools can give, there are some things they cannot give. There are certain things which the industrial worker can best obtain in practice, there are some things he can best obtain in organized schools. These things must be kept clearly in mind in extending our system of technical education farther down the line. It may help to clear up certain aspects of this problem to study for a little the general characteristics required of men who successfully fill places in the industrial field.

It must be recognized in the beginning that certain characteristics which make for success, such as executive ability, are inherited, and cannot be imparted or acquired though they may be cultivated to a certain extent. Further many boys and girls suffer from the influences of early environment to such an extent that no school or educational method or even contact with the world can ever eradicate the effects. This reform can only come by slow steps and is sometimes the most difficult problem which the educator has to confront. Aside, however, from inherited ability, and from general and cultural knowledge, the acquired accomplishments which successful industrial workers must possess may be divided into three kinds, namely, (*a*) manual skill, (*b*) scientific knowledge, (*c*) manufacturing knowledge.

The first is self-explanatory. The second refers to the knowledge of the natural scientific laws, which may, in general, be acquired from books, and which it is generally conceded may be very successfully taught in organized schools. The third refers to the knowledge of shop processes, methods of manufacturing and the finance and economics of production. It is to be especially noticed that (*a*) and (*c*) are very different in character. A workman may be very skillful at certain operations, but be wholly uninformed regarding manufacturing in general; conversely a high-grade designing engineer may and must have a broad knowledge of many shop methods and processes which he is utterly unable to perform.

The *minimum* amount of each of these three branches which the successful industrial worker must possess varies with his location in the industrial field, and the preparation which is given him to enter the field at any point must take the combination into account. These combinations may be shown graphically, and Fig. 1* represents, approximately, the relative values of the three requirements at different parts of the field, as applied, for the sake of being specific, to manufacturing based on considerable scientific knowledge, as is the case in electrical or steam turbine contruction. A similar analysis applies however, to all professional education. In the diagram, *ABCDE* represents the field of manual skill; *EDFG* the field of scientific knowledge, and *GFHIJ* the field of manufacturing knowledge. If a horizontal be drawn across the diagram the intercepts made by the lines bounding each field may represent approximately the degree of attainment in that field which the successful worker at this point must possess. The entire diagram is to be taken as approximate and relative only, as it is impossible, evidently, to lay down exact measures for such diverse requirements as represented by the industrial

* The cuts for this article are furnished through the kindness of the *American Machinist*. They were used in an article on "Trade Schools and Apprenticeship Systems" by the writer. Considerable of the subject matter of this article is taken verbatim from the article in the *Machinist* and reprinted with the consent of the editors.

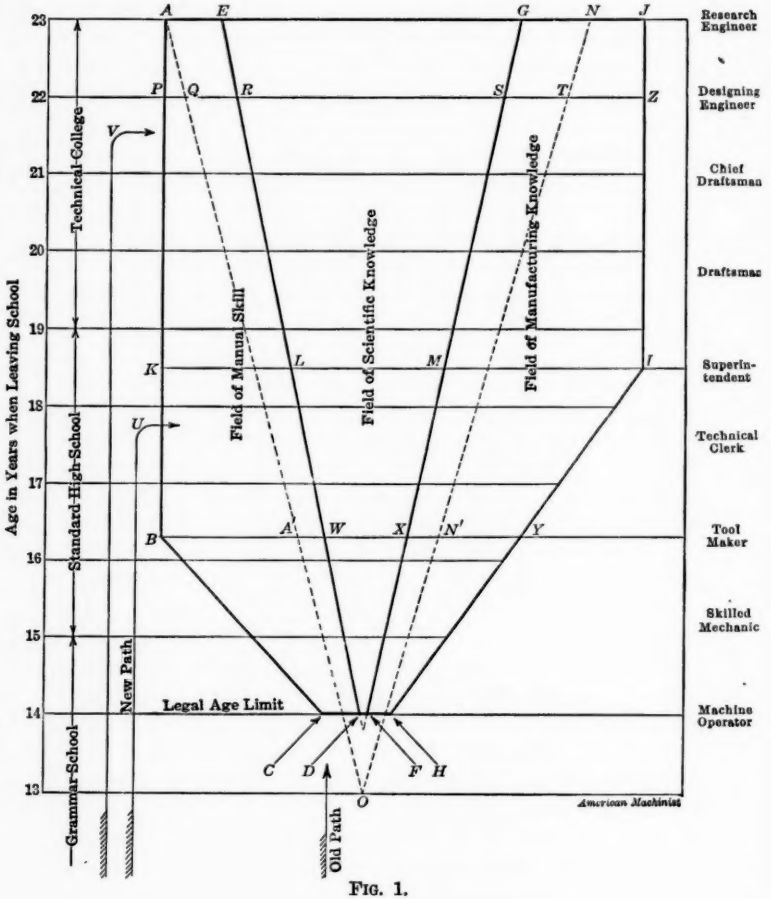


FIG. 1.

field itself. However, the general truth of the diagram must be evident. For instance, the successful superintendent should possess manual skill, scientific knowledge and manufacturing knowledge in proportion to the intercepts *KL*, *LM*,

*MI.* The toolmaker must possess a maximum of skill and be well informed in shop processes. Again for the higher types of engineers, manual skill, though highly desirable, is not so important as scientific and manufacturing knowledge. The designing electrical engineer, for example, must be well informed regarding a hundred shop processes which he is unable to actually perform; while for the highest types of engineers manual skill may be a minimum.

The position to which an industrial worker may attain is coming more and more to depend on his store of scientific knowledge. The scientific background which he obtains in school is therefore a measure of the height to which he may attain. This is not universally true, of course, as some men continue to educate themselves in *fundamentals* after they graduate, but the great majority build up their scientific attainments after graduation only as high as the fundamentals obtained in school will permit them. The *total* amount of knowledge, scientific and practical, which the boy may acquire in schools may be taken, without great error, as proportional to the *time* spent in school.

If, therefore, the height of the diagram be proportional also to the time spent in school, and, if it be conceded that practically all the scientific background may well be acquired in school, then the diagram will also indicate the length of time the boy must stay in school to be logically fitted to take a given position. For example, a boy leaving school at twenty-two with a scientific training represented by *RS* may well be expected to fill a position well up among engineers.

The amount of skill and manufacturing knowledge which can be imparted in our schools as at present organized, is small compared to the total time spent in school. And even though manual training were begun at the age of thirteen the lines *AO* and *NO* indicate the best we may do in these directions with our present school organization. Thus the aforesaid boy of twenty-two on leaving school would have manual skill as represented by *QR* and manufacturing knowledge by *ST*. The boy of sixteen whose scientific background would

logically fit him to be a toolmaker would possess manual skill as represented by $R'W$ and manufacturing knowledge as represented by $XN'$ which are only a limited part of the skill and practical knowledge required. It is to be especially noted that the proportion of these fields which the boy may acquire is increasingly greater the longer he stays in school. The general truth of the foregoing is well authenticated by statistics of our public schools and colleges.

Now most of the higher technical schools of all kinds started out to train men so that they could be introduced into the field at high levels as indicated at $U$ and $V$, Fig. 1, and fill places at those levels without further experience or preparation. This idea still lingers in the degrees which they continue to confer. Their awakening from this pleasant dream was a rude one indeed and their attitude on this point did much harm to the cause of technical education. The reasons why these higher schools have failed to accomplish their full purpose was their inability to give the graduating boy sufficient training in the right and left hand fields of Fig. 1. As a result they have had to recede from their first position, which was analogous to that of *trade schools* of high grade, and content themselves with turning out men well trained in the *fundamental sciences underlying the profession aimed at*, and with what manual skill and manufacturing knowledge it is possible to impart in the time allowable and with the facilities at hand. No doubt what measure of success the higher professional schools have attained is due largely to the fact that a scientific background is now a *sine qua non* for success in most professions.

Manufacturers and business men generally, however, have expected the colleges to confer miraculous powers on the young men and the colleges themselves are perhaps more to blame for this idea than they may suspect. Employers generally have failed to recognize the facts expressed in Fig. 1, and instead of making adequate preparation to give graduates an opportunity to obtain the necessary practical experience, have often expected them to immediately undertake

operations the successful accomplishment of which depended to a large extent on *practical* knowledge. Wherever the employer has a correct estimate of technical education and is willing to contribute his proper share towards the young man's development, good results are obtained; and this statement is not based upon hearsay but upon actual experience and observation. And herein lies the solution of the problem. In order to make technical education most effective the employer must again shoulder a small part of the load imposed by the old apprenticeship system and which he has thrown off upon the shoulders of the school. The technical school must frankly recognize its limitations on the practical side and impress upon its graduates the fact that their preparation is far from complete till these limitations have been removed by actual experience.

So long as employers refuse to employ technical graduates till *some one else* has rounded out their practical training, just so long will misunderstanding and inefficiency be the result.

Nor should the employers expect all graduates to be alike in mental ability and personal habits. Graduates of technical schools are very much like other young men in many respects and four years are hardly enough to make the naturally careless more careful, or the thoughtless more thoughtful. But all experience of fair-minded unbiased men goes to show that the average technical graduate *if given a chance,* will easily outstrip the average man who has not had such a training.

Several methods have been proposed for giving the graduate the chance to acquire what he lacks of practical knowledge. Mr. Taylor has proposed to have him drop out at the end of his first year and spend one year in a shop. Aside from the practical impossibility of this as a workable proposition, the time proposed is the worst possible. If he should drop out at all it should be at the end of his junior year, or just after he has obtained his fundamentals and just before he selects his specialty. The half-time system which is strongly advocated in some quarters will be discussed

later. The writer can, however, see no difficulty in bridging over the gap between the technical school and successful practice if *each* and *every* employer will do his small share toward giving the graduate a chance to acquire some practical training and cease to expect the school to supply him with full fledged engineers and superintendents.

The ideas advanced above apply with even greater force when we consider the lower portion of Fig. (1) and contemplate the possibility of training all grades of industrial workers by school methods. In the lower part of the diagram the proportion of practical training which can be given with our schools as at present constructed, is much less than in the upper portion. So much so is this true that to bring the grammar and secondary grades anywhere near the requirements of the industrial workers means the creation of new kinds of schools and redirecting our present ones. This field is at present the battle ground of the advocates of several different systems all aimed at bringing education in line with practice. It may be useful to review these various movements.

The old apprenticeship systems, taking the boy at the bottom of the diagram, slowly worked him upward, the apprentice acquiring, largely by absorption (seldom by actual teaching) the combination of the three elements which located him in the field. It must be remembered that the distance to the top was not then so great, as scientific knowledge and the economics of manufacturing have grown tremendously during the past twenty-five years; but even then the way was long and toilsome. The passing of the old apprenticeship system is not to be regretted, as it is hard to imagine a system so uneconomic and in some respects so unfair as this system. The writer, himself, served one of these " good old-fashioned apprenticeships " under extremely favorable circumstances, has also had the opportunity to observe many others, and can therefore, speak from actual experience.

Changed methods of production, and the extension of the principle of division of labor have rendered these old sys-

tems obselete; and progressive manufacturers long ago realized that the old apprenticeship methods were not only impossible under the new conditions, but that they were also uneconomic. Many concerns in this country have, therefore, within recent years introduced new forms of apprenticeship systems which are worth more than a passing thought. They are varied* in their character, ranging all the way from slight modifications of the old system to high types of industrial schools; and even a hasty description of any of these is beyond the scope of this article. It is to be especially noted, however, that, in practically all of them, *organized* instruction is provided at least on the practical side; that in many of them, some provision is made for school instruction in the related scientific branches of the art; and that only in the few, such as that at the Lynn Works of the General Electric Co., is organized instruction in all three elements of Fig. 1 imparted in a separate training school *before* the boy is transplanted to the shop proper. This last type of apprenticeship system brings the boy into the industrial field partially equipped at least, with all three of the required elements, in exactly the same way it is proposed to bring him in under a system of industrial schools. While, therefore, the old apprenticeship system is dead the new systems are very much alive and growing; the most highly developed rivalling good industrial schools; and any discussion of industrial instruction must take account of this phase of the question.

Confining the discussion for the present, to the lower part of the diagram, Fig. 1, what are the advantages and what the disadvantages of training industrial workers entirely in the factory; and what the advantages and limitations of the public industrial or trade school which is entirely independent of the factory?

There can be no doubt that a well-organized apprenticeship system presents many advantages. The boy may earn some-

* For a very masterly discussion of modern apprenticeship systems see Bulletin No. 6 of 1908, United States Bureau of Education, by Carroll D. Wright.

thing while he is learning his trade; and this is an all important matter to many parents. So important is it that should compulsory educational laws compel the attendance of boys in industrial schools longer than at present, the state may be in duty bound to assume, in some measure, the financial deficit created by such action. He would possess no false ideas of his value, which might be the case with boys partially trained in industrial or trade schools and as students of technical schools of higher order are likely to hold. And beyond all doubt the major part of the necessary manufacturing knowledge, the knowledge of shop methods, the knowledge of *men,* and the thousand and one details of information that go to make up the well-rounded-out worker can be acquired only in the atmosphere of the art itself.

On the other hand the apprenticeship system as usually organized is very wasteful of time, much of the boy's time being applied to work which is more or less drudgery. This is, of course, not economical either for the boy or the employer; and wise manufacturers now look after this point carefully. The tendency of the shop atmosphere is to accent the shop side, to the neglect of the academic side without training in which no modern trade instruction can be considered effective. Carroll D. Wright as a result of a careful survey of this field says: " The majority of the concerns having an apprenticeship system fail to provide in their works definite instruction in the related subjects of mathematics and science. An investigation shows that they 'encourage' boys to attend public evening schools, mechanics institutes, and the Young Men's Christian Association classes. Careful investigation shows that this encouragement lacks definite results." Many of the industries are so narrow that even with the best form of an apprenticeship system now in existence the outlook of the worker would be too narrow to meet the specifications of modern ideas of citizenship. An apprenticeship system will, necessarily, be operated in the interest of the employer and none but the best boys will be taken into the shop. Many manufacturing concerns cannot afford the neces-

sary facilities for instruction in the allied academic branches. Again there are some industries, like the shoe industry, in which the work has been so minutely divided that apprentice instruction is no longer possible to any appreciable degree. And lastly there are very few companies large and prosperous enough to afford a training school of their own that would give the required practical and academic training. These last five items show clearly that even could the apprenticeship system be fully developed many boys must, necessarily, be left uncared for or their education must, necessarily, be defective should we attempt to depend on apprenticeship systems alone. And, what is still more important, the apprenticeship systems make no provision for the so-called "wasted years" from the age of fourteen to sixteen which are so valuable for industrial training, boys generally not being wanted in the trades much before sixteen years of age.

The industrial or trade school is economical of time and can therefore impart a given degree of manual skill in fundamental operations in less time than is usually required in the shop. It may be and should be open to *all* and each and every student may be given the same drill in fundamental operations since the complications of the shop are not present to interfere. The instruction even in the practical side may be thoroughly systematized and not be haphazard as in the shop, the work being illustrative in its character and the sequence such that maximum efficiency is attained over a wide range. The academic training in the related sciences can be given in a school to perfection, and with definite assurance that each and every boy receives such instruction. The industrial school cares for the boy or girl during the wasted years and if properly conducted should help the boy or girl to choose a trade more intelligently and place him, or her, in that trade with no inconsiderable amount of preliminary training.

On the other hand, the industrial or trade school cannot *perfect* a boy either on the manual side of his art or in a knowledge of the shop processes and details of manufacture peculiar to his chosen calling. It can supply fairly well the

middle field of Fig. 1 but can never give the boy the full training required in the field on either side. It is true that there are a few trades so simple that *trade schools* may educate boys to a point where they are fit to take their places almost at once in the ranks of finished workmen; but these are rare, and in practically all cases the graduate of the trade school must be adapted to a greater or less extent before he is fully efficient in the shop. No doubt we have obtained some false ideas on this point from the vast amount of literature which has been published regarding German industrial schools. Much of this literature is very misleading. Mr. F. A. Halsey in an article entitled* "Training Mechanics in Germany" says as the result of his observation, "If trade schools are a practical thing the fact remains to be proven, instead of proof, based on supposed German experience, being taken for granted. In so far as we are doing anything with such schools we are blazing a new path."

It would seem then, that neither apprenticeship systems nor vocational schools as at present contemplated can successfully fill the requirements of the industrial field. If however, there were some way of taking advantage of the good points of both, the question could be solved at least to some extent. An effort to accomplish this end is found in the so-called half-time and cooperative systems, under which the boy obtains his practical instruction in the shop and his academic training in the school, special arrangement being made between the manufacturers and the schools for this purpose. Undoubtedly, the idea has many merits; and when operated within its natural limits and in a suitable environment will produce good results. It is limited in its application, however, and cannot be considered a solution of the greater and more general problem; there are many manufacturing districts, on the one hand, which have not and cannot well have the necessary school facilities to operate such a system; and there are many schools so situated as to be unable to obtain the necessary cooperation of manufacturing interests. It

* See *American Machinist*, October 27, 1910.

has the further drawback of placing the school more or less under the domination of private interests, thus leaving no assurance that the training offered will continue to be as broad as would be insisted on in schools entirely under public control. It is almost self-evident that in any public school *system* the school control must be paramount; and the interests of education and those of manufacturing are far from being always harmonious.

In considering the advantages and limitations of these co-operative courses, the general ideas conveyed in Fig. 1 must be kept in mind. If the school is for the purpose of training mechanics, toolmakers, foremen, etc., the acquirement of manual skill should be a prominent feature of the shop work. If, however, the object be the training of men for the higher levels of the engineering field the shop instruction should lay more stress on the finance of production and the discussion of shop methods, and less on the acquirement of manual skill. The writer appreciates very fully the value of shop skill and the desirability of a long course of training in actual shop-work both for their intrinsic value and for the beneficial influence of the latter on the young man's outlook toward shop men and shop methods. But in the highest grades of technical schools in this country with curricula containing little more than the bare fundamentals of the scientific side of engineering necessary to give the graduate a foothold in the field, the *average* graduating age is about twenty-three. This is about as late in life as a young man should be allowed to remain in college. The addition of a long course of shop-work to this curricula can be accomplished only in one of two ways—namely, the lengthening of the college course or the reduction of the scientific background, both of which are extremely undesirable. Such shop training as is given must therefore lay stress on the finance and methods of production rather than on manual skill which is of secondary importance to this class of men. The fundamentals of the finance of manufacturing can be given in the class room better than they can in the shop; and it is not

necessary or possible for the young engineer to acquire a full knowledge of shop processes by actually performing them.

Furthermore while the writer, as before stated, fully appreciates the value of actual shop work, he does not believe that a boy's attitude towards shop work can or should be taken as a criterion of his value as a prospective engineer as some advocates of the cooperative method would insist. The fact that a boy is fond of shop work is just as often a sign that he is not fit to be more than a mechanic as it is a sign to the contrary. No less an authority than Carroll D. Wright in discussing modern apprenticeship systems says: "In so far as the apprenticeship system does not over-emphasize academic instruction, and there is no evidence that it ever will, it will offer great inducements to the boy who does not want to study." All teachers in technical colleges are familiar with the boy whose parents think him an embryo Edison or Steinmetz because he is fond of tinkering at practical work; and who cannot understand why he is found to be unfit for an engineering course simply because he cannot understand mathematics and physics. On the other hand, some of the brightest and best engineering students of the many hundreds who have passed under the writer's observation, and who have made marked success in engineering, were not only hopelessly unskillful with their hands, but had little liking for actual constructive work. High mental development along scientific lines does not necessarily coexist with manual skill and shop leadership; and the high grade engineer *must* possess the first though not necessarily the last two.

The problem which confronts industrial education for the lower grades is, after all, exactly the same as that which confronted the higher technical schools when they began, and their experience is not only a valuable guide but also an indication of what will most probably be the solution of the problem.

If elementary schools are organized with the expectation of supplying the industrial field with full fledged mechanics, draftsman, etc., nothing but disappointment awaits both man-

ufacturer and teacher. If schools are formed, however, where *general fundamentals* may be taught and if all employers and manufacturers are willing to do their share of "adapting" the boys and girls so trained, to the special requirements of their business there is no doubt but what the problem can be solved to a large extent.

Few manufacturers can have well developed apprenticeship systems like that of the General Electric Co., at Lynn, but all can do considerable adapting if furnished with good material. This material cannot be trained in the ordinary school any more than embryo engineers can be trained in classical colleges and the problem requires the redirecting of our lower grade schools. Much thought and considerable experimentation has already been put upon this interesting and important work and such experimental schools as have been organized, though not as yet forming anywhere a complete system of schools, have indicated some of the possibilities.* There seems to be no reason why *elementary industrial schools* cannot be organized almost anywhere in which elementary manual training and industrial fundamentals of *surrounding industries* may be taught, in addition to such general education as is needed for intelligent citizenship. Such schools should receive pupils not earlier than the thirteenth year and the course could be two years in length. These schools should be followed by what have been named, *intermediate industrial* schools which might carry the boys or girls to the age of nineteen if it proved feasible to hold them that long. The first two years in this school would be devoted to the scientific and practical *fundamentals* which underlie a *group* or *groups* of allied industries. The last years could be more closely specialized and partake more of the nature of trade school work. By such a system a natural sorting process could be maintained and the pupil brought closer and closer to the requirements of the industrial field. Such a system would relieve the manufacturer of a part of the bur-

* See the "Factory School of Rochester," by G. M. Forbes; published by the Society for the Promotion of Industrial Education.

den which at present is too heavy for many and at the same time would not burden the public with so heavy an investment as would be necessary for a complete system of trade schools. Such a system of schools is shown graphically in Fig. 2.

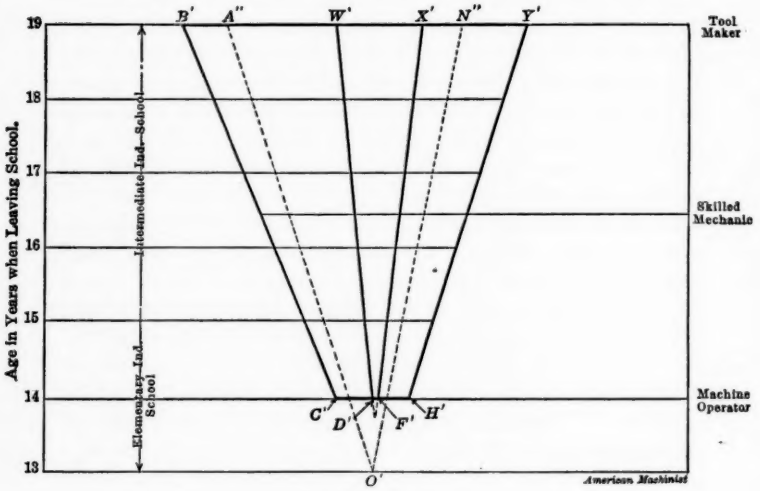


FIG. 2.

Here the requirements of the toolmaker, the most highly skilled mechanic as indicated by the *BY* in Fig. 1 forms the upper boundary of the diagram in Fig. 2. The lower line *C'H'* in Fig. 2 is the same as *CH*, Fig. 1. The total height of the diagram, Fig. 2, is six years instead of three years in Fig. 1. The scientific background (*WX* in Fig. 1 and *W'X'* in Fig. 2) is the same in each case; but the amount of practical training which may be given in Fig. 2 as indicated by the dotted lines brings the student very much closer in line with the requirements of the field.

These intermediate schools would not prepare for higher technical schools but for industrial life. The writer is well aware that a strong sentiment prevails, particularly among

school men, that all schools should lead to something higher and be "open at the top." While he is heartily in sympathy with the sentiment he can see no sense in keeping them open at the top for those who cannot enter at the bottom of the school next higher up, or *who have no desire to enter.* The present system of elementary schools is very unjust, as far as the great majority is concerned, for it fails to provide the training absolutely necessary to give most boys and girls a start in life.

The great majority must work at industrial pursuits and the parents of boys and girls may be trusted, in general, to do the best for them educationally as far as their financial means will permit. A few boys may be deflected through these industrial schools, into the field, who should have had greater advantages. For these the continuation school and evening schools which must be established to supplement the industrial schools discussed above, will afford the opportunity to rise, if their ambition warrant it, and they will have the ability and training to earn the money necessary for their further development.

And just as the elementary schools must be redirected so must be the high schools. This movement is already well under way and we already have secondary schools whose primary object is to fit for life and not for college. Just as the university offers many roads to the world's work so in time the high schools will offer many avenues outward, of which that leading to the college will not be the most important by any means. The character of these new high schools will vary with location and environment and their scope will range all the way from that of the existing classical high school on one hand to the trade schools on the other, for these latter really fall under the head of true secondary education. Whether a single building will contain but one type of school or several is purely a matter of local surroundings.*

* Mr. A. D. Dean, Chief of the Division of Trade Schools in the State of New York, has discussed this point in his book just issued and en-

The greatest difficulty in the way of any system of industrial schools of the lower or secondary grades will, no doubt, be the financing of them so that students may be held in school long enough to receive some real benefit. It may be that in the latter years at least, of trade school courses, students will have to be given a chance to work on real productive work in order that they may earn as they learn. We have good reason to believe that even this is possible.

It must also be kept in mind that there is not but one way of accomplishing the desired result. The question is not, *can* it be done *this* way or *that* way, but how can it *best* be done. In many places half-time schools may be successfully organized; in many others peculiar local conditions will make a trade school desirable; but the general solution of the problem must be by means of industrial schools where such fundamentals are taught as will prepare boys and girls for the industries of a large surrounding territory supplemented and encouraged by the interested cooperation of every employer.

Such a remodelling of our primary and secondary grade schools will, therefore, offer a series of openings into the industrial field by means of a system of technical schools running all the way from the eighth grade to the highest university we possess. And these technical schools will not lead to each other any more than the professional schools of any one university lead to one another but will lead outward to the world's work. The *fundamental* and *general* knowledge which must always form the background of any school system will be continuous and grow steadily from the first grade to the highest *general* university courses.

And finally it must not be forgotten that the aim and end of all education should be to train men to *think*, not only with regard to their occupation in life, which may be very narrow, but also with regard to the broader industrial prob-

titled "The Worker and the State." His discussion of the general problem and his diagram of the particular point covered in this paragraph will repay reading.

lems of the day which surround and intimately affect him, and which at present he is often blindly seeking to solve. The instruction which will help him to enlighten the industrial worker regarding these problems lies almost entirely without the three fields of Fig. 1, though it is closely interwoven with them. Training for manual skill and in shop methods does not make a man an intelligent voter; no more does the study of the higher sciences give the broadened outlook and sympathetic view of his fellow man which belong to the truly cultured man. This broader instruction which makes for better citizenship can not be well imparted in any shop school or apprenticeship system and if every worker is to receive that proportion of such instruction which should by right belong to him, it can come only through some form of organized public instruction.

It is almost certain that these changes which are even now on the way will affect the work of the technical colleges of the higher grade. For one thing they should result in a better definition of what the work of the higher technical schools should be and what portion of the industrial field they should logically be expected to prepare men for. The higher technical schools are to-day preparing men for all manner of callings who could receive ample preparation in schools of lower grade and less costly equipment and in the preparation of the highest type of technically educated man they are often greatly handicapped by the overabundant supply of mediocre material.

The articulation of the technical college with these new forms of high schools has yet to be worked out and the changes discussed in the preceding paragraphs will have a large bearing upon the resulting arrangement. The idea already prevails in many quarters that the technical high school and it alone should perforce lead to the technical college. Nothing could be farther from the truth of the situation. While the preparation given in the technical high schools should not, in the beginning at least, debar a boy from entering the technical college, the best preparation which he can obtain for the

purpose must be found in the older form of high school. The engineer of all grades is more and more being called upon to solve problems of greater and greater economic significance and must therefore be prepared to meet men of liberal education upon an equal footing. His preparation before entering the technical schools should therefore be as liberal as possible for the closer the specialization the broader should be the foundation on which it rests. A sound mathematical preparation he must have, but the remainder of his preparation should be as broad as possible, giving liberal subjects the preference over scientific studies which he can and will obtain in ample time after entering college and in a much better manner. *All special training* must be backed by *general knowledge*. Specialization means a tapering off process in preparation for life's work and should be deferred as long as possible while general and fundamental training should be carried on as long as possible. The adjustment of entrance requirements to these new conditions will require some thought for it may not be so easy as it appears to decide what studies may well be accepted for entrance to the higher school without doing injustice to these new secondary schools on the one hand and making sure on the other that the student has the *maturity of mind* to pursue the more advanced work of the technical college. It may be perfectly possible for a boy to graduate from some forms of high school and not possess this essential quality; but it by no means follows that the entrance requirements as now laid down by the technical schools are the *only* ones which will secure this mental maturity.